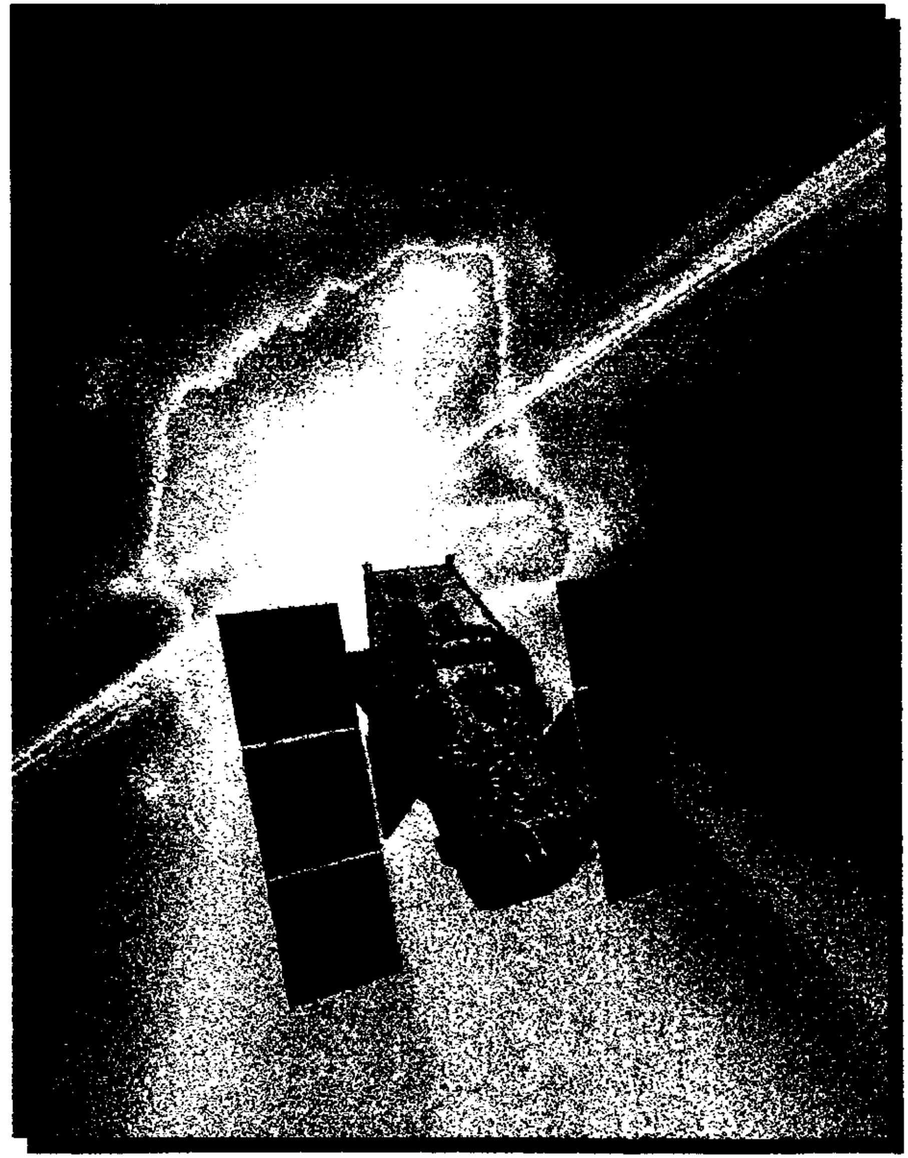
410.4-RVW-0021

Swift

Swift Confirmation Review

February 12, 2001



Agenda

• Introduction	Mr. Tim Gehringer
• Science Overview	Dr. Neil Gehrels
• Mission Overview/Assessment	Mr. Tim Gehringer
• Explorers Recommendation	Mr. Tony Comberiate
• Discussion	Dr. Ed Weiler

Mission Overview

Mission Objective: To Determine the Origin of Gamma-Ray Bursts and to Use Them to Probe the Early Universe

Principal Investigator: Dr. Neil Gehrels Goddard Space Flight Center

Instruments : Burst Alert Telescope (BAT)- (GSFC) Provides the burst detection and location
X-ray Telescope (XRT) (PSU, UL, OAB)-Provides Afterglow position, Spectroscopy and Light Curves
Ultra-violet and Optical Telescope (UVOT) (PSU &MSSL)- Provides UV Light curves, Optical Finding Chart, and follow-up observations

Principal Institutions:

Goddard Space Flight Center (GSFC) - BAT Instrument, Optical Bench, Science Center, Science Data Processing, Project Management, EPO
Pennsylvania State University (PSU) - XRT, UVOT, Mission Ops Center, EPO
University of Leicester (UL)- XRT, Science Center
Mullard Space Science Lab (MSSL) - UVOT instrument
Osservatario Astronomica di Brera (OAB) - XRT Mirrors and Mirror Support
Agenzia Spaziale Italiana (ASI) - Malindi Ground Station, Science Center
Los Alamos National Laboratory - BAT Trigger Algorithm
University of California - Ground Telescope coordination
Sonoma State University, California - EPO lead institution

Mission Overview

Mission Design:

Orbit: Inclination ≤22°; 600 km Circular

Mission Lifetime: 3 years (1 year minimum success)

Launch Vehicle: Delta 2420, 10 ft fairing and 6915 adapter

Spacecraft: ZMB, 3 axis stabilized, 6 reaction wheels, 3 arcmin control, 3 arcsec knowledge

Mass: Observatory-1269.5 Kg estimated; Launch Vehicle capability is 1550Kg to 22° inclination x 600Km-- 22% Margin

Power: Observatory Requirement: 891.7 Watts; 31% Margin (276 Watts)

C&DH: TDRSS 4th Gen. Transponder (GFE to SA), 5Gb/day data volume, 7 passes/day to Malindi (ASI supplied)

Operations: MOC @ PSU, Science Center @ GSFC science data processing @ GSFC, UK and Italy

Mission Programatics:

Launch Date: Sept. 30, 2003 from KSC (6 months schedule slack to launch)

Cost Capped at $167 M

Major Contracts:PSU, Spectrum Astro, LANL, Sonoma State,UCB

International Agreements: PPARC/LU, PPARC/MSSL, ASI

Swift Confirmation Review Process

- The Swift Confirmation Process:
  - Instruments/Spacecraft/ Mission PDRs — August, 2000
    - 6 different PDR's chaired by Code 300
    - Peer Reviews were held on all mission element subsystems prior to PDR.
  - Confirmation Assessment Review (CAR) — November, 2000
    - 2 committees reviewed Swift
      - Program Office committee chaired by Dennis McCarthy - Swales Assoc.
      - HQ sponsored committee chaired by Dr. Dave Gilman - NASA/LARC
  - Confirmation Readiness Review (CRR) — January 12, 2001
    - Goddard PMC, chaired by Bill Townsend
  - Confirmation Review — February 12, 2001
  - All CAR Issues were closed at the CRR

Action Items from the CRR

- Actions from the CRR:
  - Swift Project to confirm to the GPMC that an Instrument Systems/Instrument Module Manager is in place.
    - Paper work is in place
  - Swift Project to complete Risk Management Plan and obtain SMO concurrence.
    - Plan complete. Obtaining SMO Concurrence
  - Swift Project to provide a complete risk list and mitigation action plan to SMO for review prior to the February MSR.
    - List completed and forwarded to SMO.
  - Swift Project to present a brief summary of their Surveillance Plan.
    - In work to be completed by March MSR.

Swift Action Items from the CRR (Cont'd)

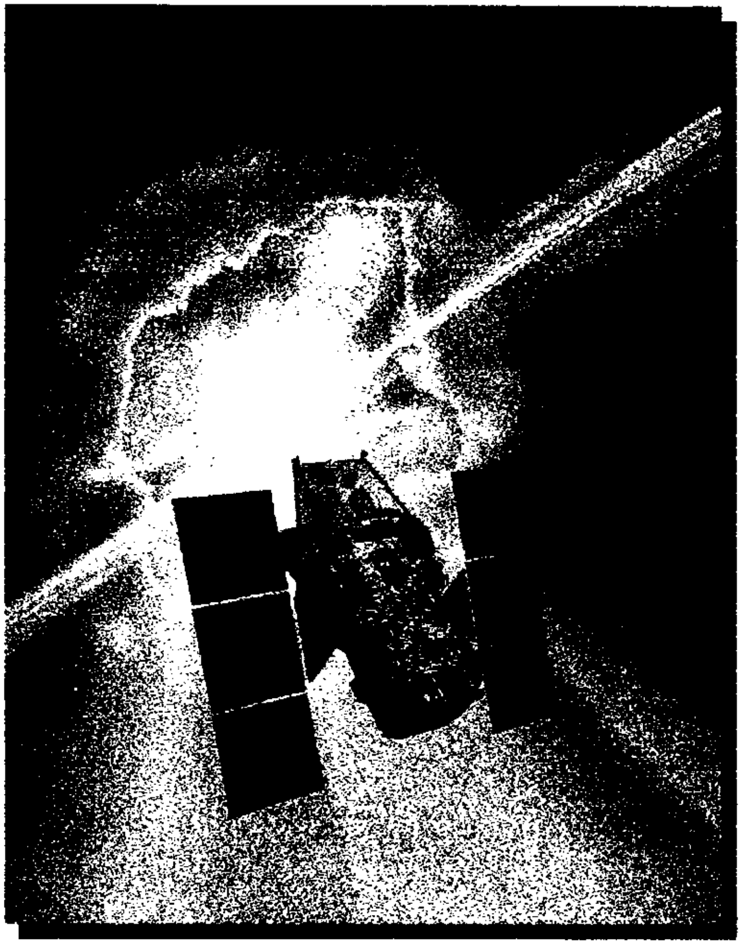
- Actions from the CRR (continued):
  - Complete the contamination plan and flow the requirements down to Spectrum Astro and to the other players.
    - Contamination Plan Completed. Flow down of requirements to the spacecraft will take an additional month
  - Create a staffing plan to utilize additional civil servants for BAT and spacecraft risk mitigation.
    - Staffing plan complete. Negotiating details of plan with code 500.

Science Overview

Dr. Neil Gehrels
NASA/GSFC

Principal Investigator

Swift Science
Catching Gamma Ray Bursts on the Fly



Science Objectives

- Determine origin of GRBs
- Use GRBs to probe the early Universe
- Perform hard X-ray survey

Swift Science Team

Hardware Institutions:

Goddard Space Flight Center:
Management, BAT
Penn State University:
XRT & UVOT integration
Leicester University:
XRT detector
Mullard Space Science Laboratory:
UVOT
Osservatorio Astronomico di Brera:
XRT Mirrors
Sonoma State University, California:
EPO
Agenzia Spaziale Italiana (ASI):
Ground Station

Lead Institution:

Goddard

PI: Neil Gehrels

Lead University Partner:

Penn State

PSU Lead: John Nousek

Countries Involved:

USA, Italy, UK

Current GRB Knowledge

From CGRO BATSE and Beppo SAX:

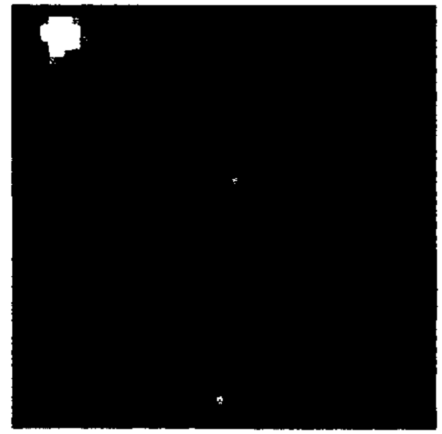
- Long GRBs occur at high redshift, z~1.
- Faint host galaxies seen for most GRBs.
- GRBs and extremely bright beacons from distant universe
- Largest explosions since Big Bang: E ~10^{52} ergs

From Theory:

- Bursts are due to massive star collapse (hypernovae)

'or'

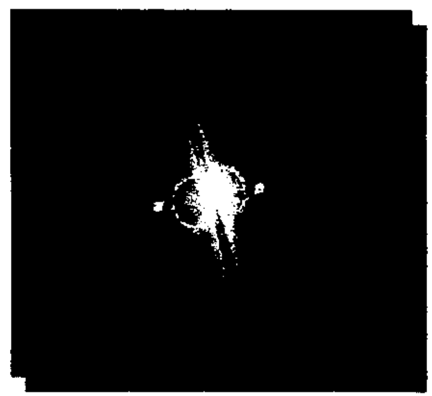
- Bursts are due to compact star mergers



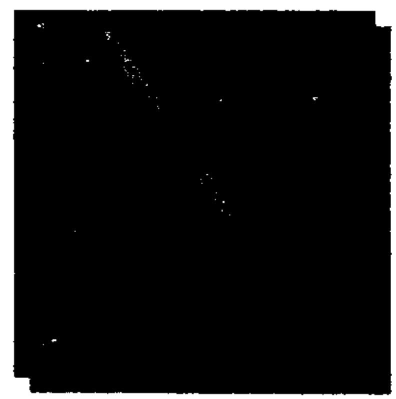
970228

Hubble

Theory



Star Merger



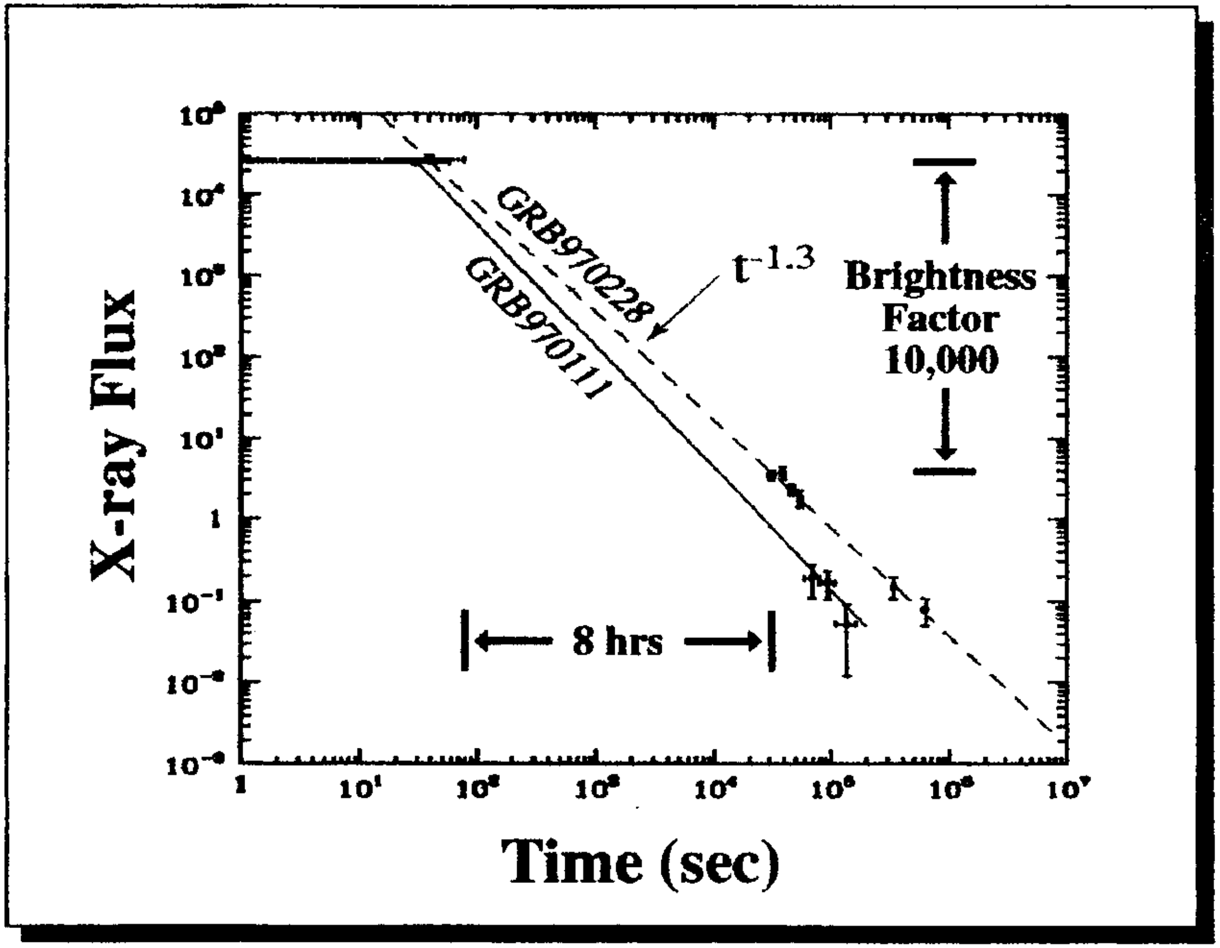
Hypernova

Current GRB Excitement

Rome GRB Workshop - Oct. 2000

- GRB ghosts: Bright GRBs with no optical afterglow.
  - 1/3 of all bursts
  - Heavily absorbed in star formation clouds?
  - High redshift z>5?
- GRBs with no host galaxy. Different class?
- Short GRBs with no observations to date. HETE will begin this study
- 3 GRBs possibly associated with supernovae
- Theoretical prediction that GRBs occur out to earlier epoch of star formation at z>15. Probable that 40% of GRBs have z>5.

Current Gap

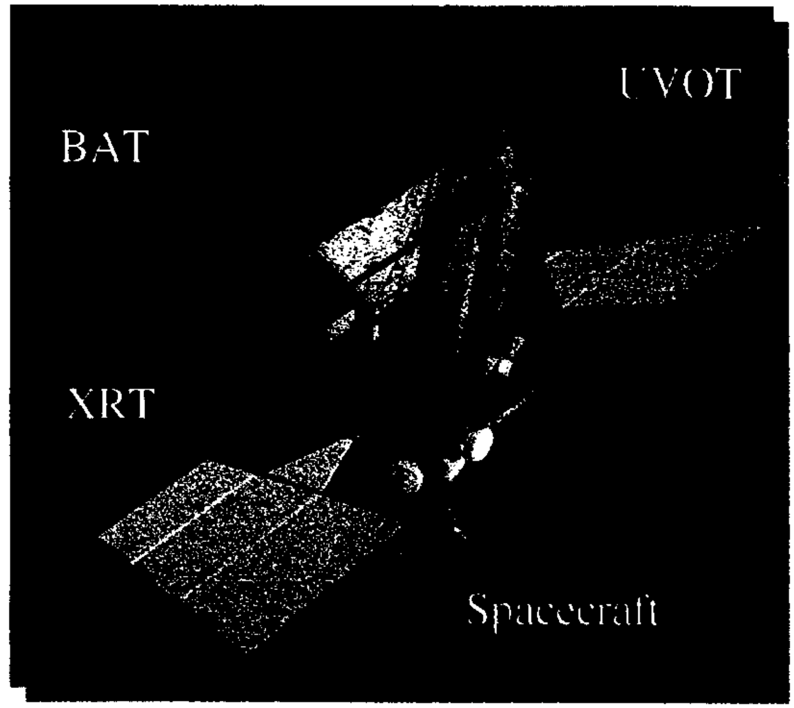


X-ray Flux
Time (sec)
GRB970228
GRB970111
$t^{-1.3}$
Brightness Factor 10,000
8 hrs

Swift Instruments

Instruments

- Burst Alert Telescope (BAT)
  - New CZT detectors
  - Detect ~300 GRBs per year
  - Most sensitive gamma-ray imager ever, 5x BATSE
- X-Ray Telescope (XRT)
  - Arcsecond GRB positions
  - CCD spectroscopy
- UV/Optical Telescope (UVOT)
  - Sub-arcsecond imaging
  - Grism spectroscopy
  - 24^{th} mag sensitivity (1000 sec)
  - Redshift measurements
  - Finding chart for other observers



Spacecraft

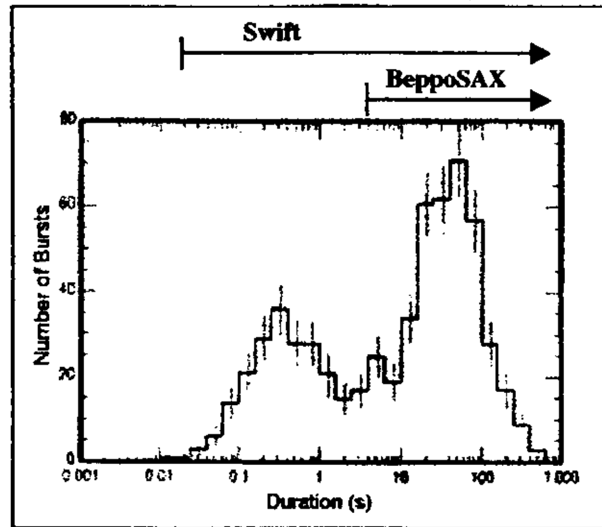
- Autonomous re-pointing in 20 - 70 sec
- Onboard and ground triggers

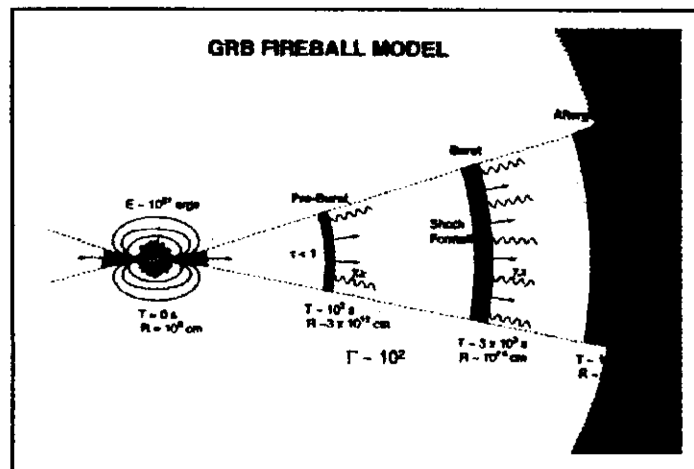
Swift Science

Determine Origin and Classification of GRBs

- Multiwavelength observations on all timescales
- Identify host galaxies and measure offsets
- 1000 GRB counterparts
- More sensitive than previous missions
- Intriguing current burst examples

GRB 980425 --
GRB 970228 -- supernova associations
GRB 980326 --
GRB 000301c -- no host galaxy, microlensing
GRB 990326 -- no host galaxy
GRB 990123 -- bright optical transient



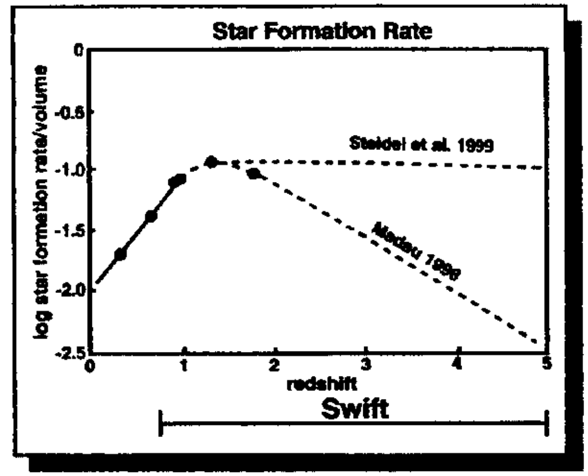


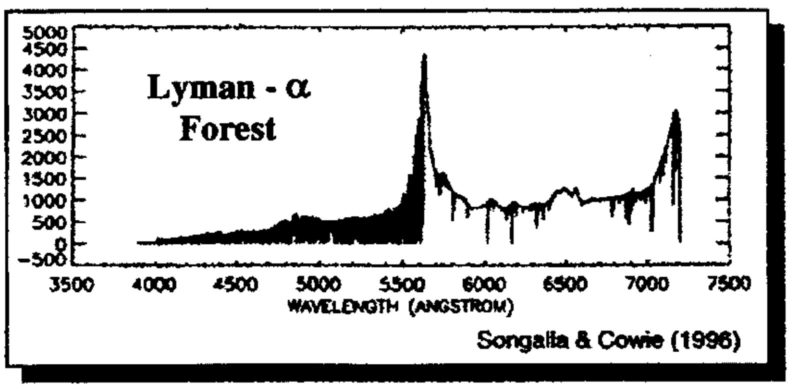
Swift Science

Use GRBs as early-universe probes

Swift provides new tools to study the universe.

- Measure star formation history of massive stars to $z > 5$
- Determine dusty material in distant galaxies (deduce extinction curve)
- Determine structure and ionization of intergalactic medium to $z > 4$

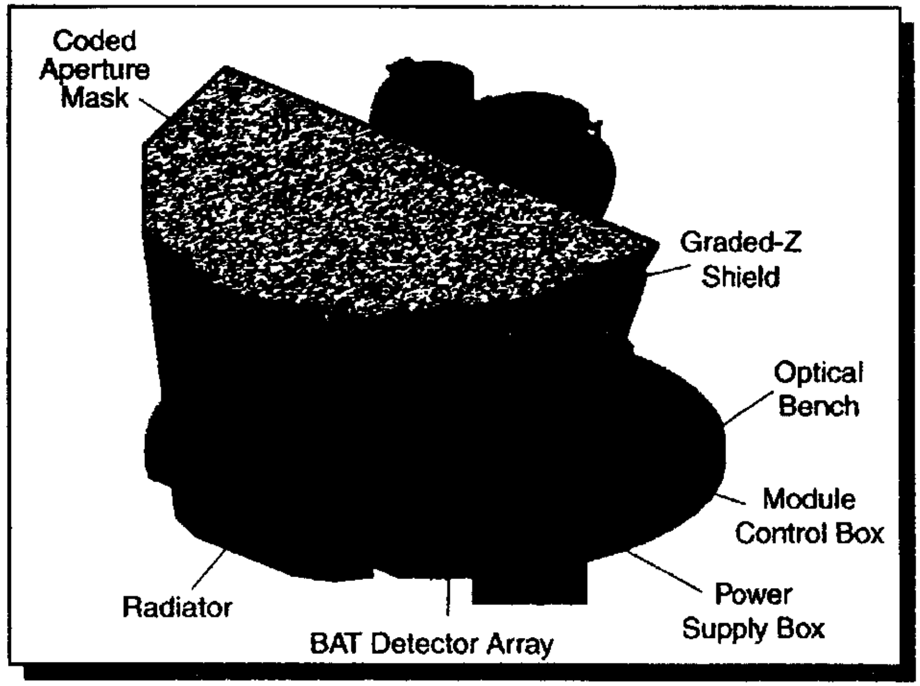




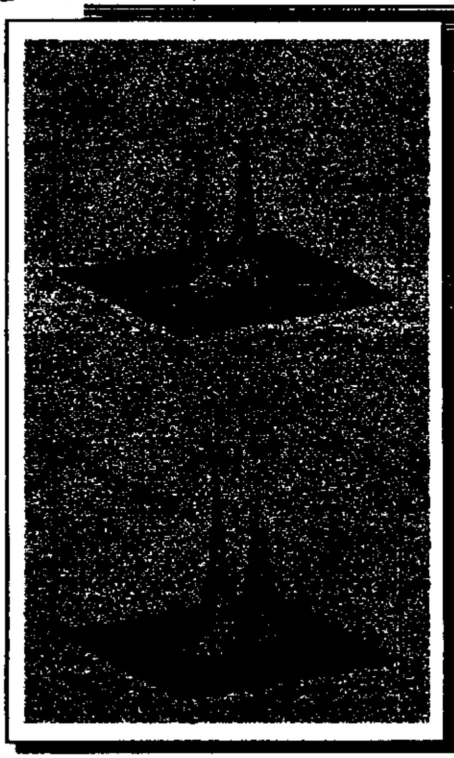
Swift Instrumentation

I. Burst Alert Telescope (BAT)

- Real time gamma ray burst positions
  - half coded 1.4 steradian FOV
  - 5200 cm^2 CdZnTe pixel array
  - 10 - 150 keV band
  - based on INTEGRAL Imager design
  - 5 times more sensitive than BATSE
  - ~ 1 burst per day detected (depends of logN-logS extrapolation)
  - angular resolution of 17 arc-minute giving positions of 1 - 4 arc-minute
  - onboard processing to provide prompt arc-minute position to satellite and to the ground



Swift Instrumentation

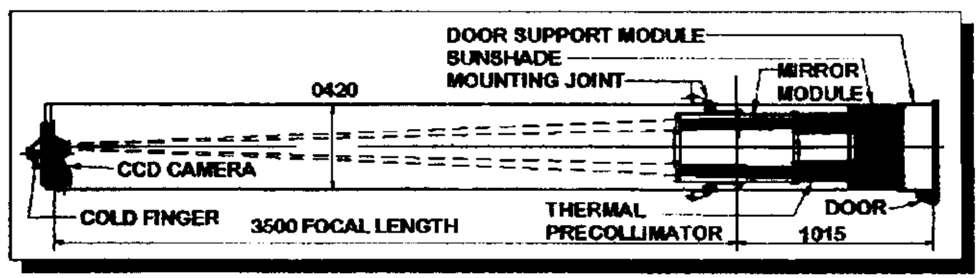


II. X-ray Telescope (XRT)

- Flight spare JET-X module
- 15 arc-second half energy width
  - sharp core will yield ~5 arc-second locations
- 3.5 m focal length
- Total effective area
  - 110 cm^2 at 1.5 keV
  - 65 cm^2 at 6 keV

XRT Mirror Module

- **CCD array covers 0.2-10 keV band**
  - **use spare XMM chip**
  - **24 x 24 arc-minute field of view**
  - **Cooled to -100 degrees C**



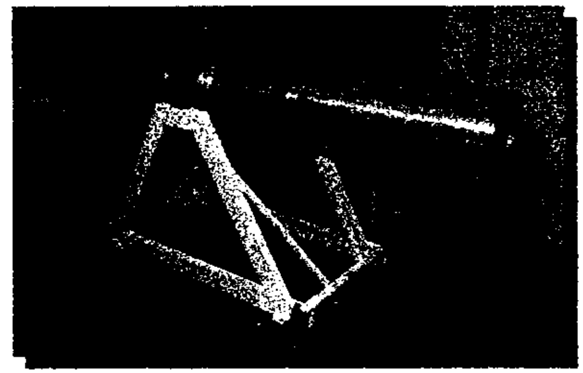
Swift Instrumentation

III. UV-Optical Telescope (UVOT)

- Based on XMM OM to minimize cost and risk
  - Covers 170 nm to 650 nm
  - 30 cm Ritchey-Chretien telescope
  - 24 mag in 1000 s with 17 arc-minute FOV
  - Detector is image intensified CCD array
  - Unique coverage 20-70 s after burst trigger
  - Positions to 0.3 arc-seconds using onboard image registration

- UVOT will be simple reproduction of XMM OM

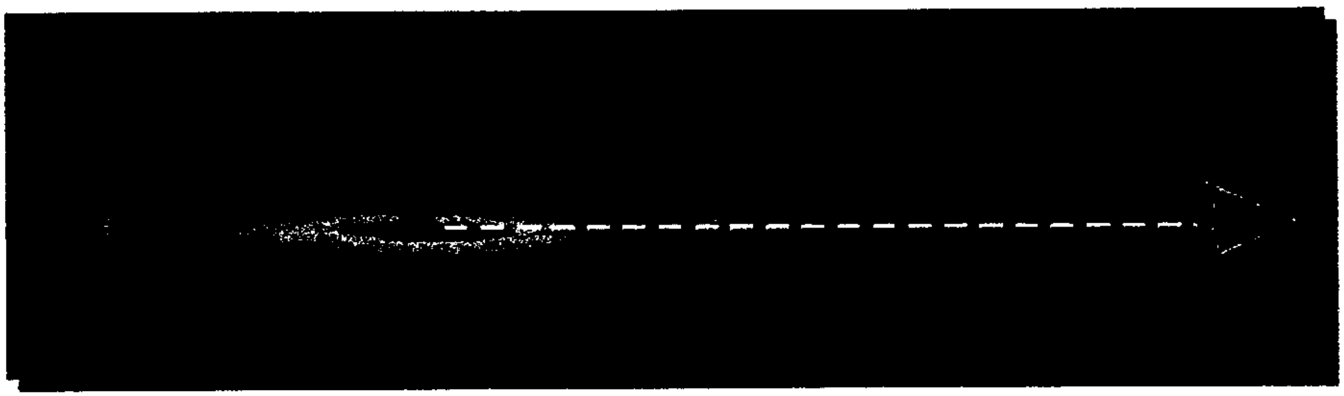
XMM OM



Filter Wheel

Bonus Science

- **Swift will perform first sensitive hard x-ray survey**
  - ~ 0.5 mCrab sensitivity
  - 30 times more sensitive than HEAO A-4 (1979)
  - Primary science of lost ABRIXAS mission
  - Search for predicted population of absorbed Seyfert II
  - Finder for Chandra, XMM, SIRTF, & SCUBA

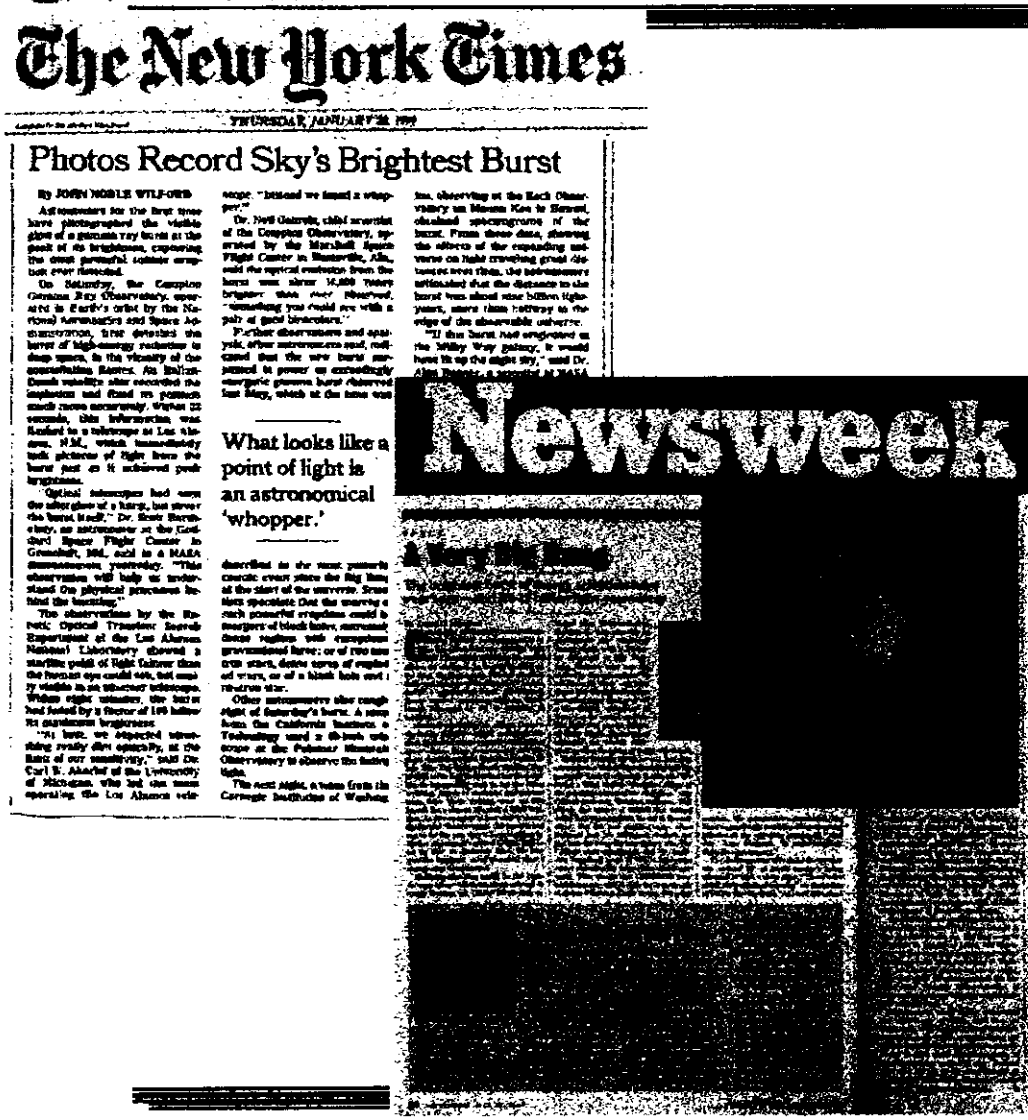


- **Swift will be the fastest response space observatory ever**
  - Panchromatic capability
  - New resource for astronomy

Level 1 Requirements

No.	Parameter	Baseline	Minimum
1.	Number of GRBs observed	300	200
2.	BAT sensitivity	5x BATSE	3x BATSE
	(redshift distance sensitivity)	(z>15)	(z>10)
3.	Number of afterglows studied	200	75
4.	Spacecraft response time	75 sec	100 sec
5a.	BAT position accuracy	5 arcmin	10 arcmin
b.	BAT position time	20 sec	30 sec
6a.	XRT position accuracy	5 arcsec	10 arcsec
b.	XRT position time	100 sec	150 sec
7a.	UVOT position accuracy	0.3 arcsec	1 arcsec
b.	UVOT position time	270 sec	350 sec
8.	Hard X-ray survey sensitivity	0.6 μCrab	5 μCrab
9.	Mission Lifetime	3 years	1 year

Swift E/PO Program



- Community involvement in Swift
  - Data distributed immediately over Internet
  - World community participation in Swift science
  - Archive sites in USA, UK, and Italy
- Public involvement in Swift
  - Gamma ray bursts capture public attention
  - Strong education program proposed
  - Swift Team enthusiasm for outreach

Education and Outreach

All programs are underway!

- Education Program
  - Teacher Activity Booklets
  - Space Mysteries Series
  - GEMS with Lawrence Hall of Science
  - Educator workshops
- Outreach Program
  - Web site developed http://swift.gsfc.nasa.gov
  - Song, video, and information packet
  - Posters
  - Display booth
- Museum exhibits: UK, SEU Forum

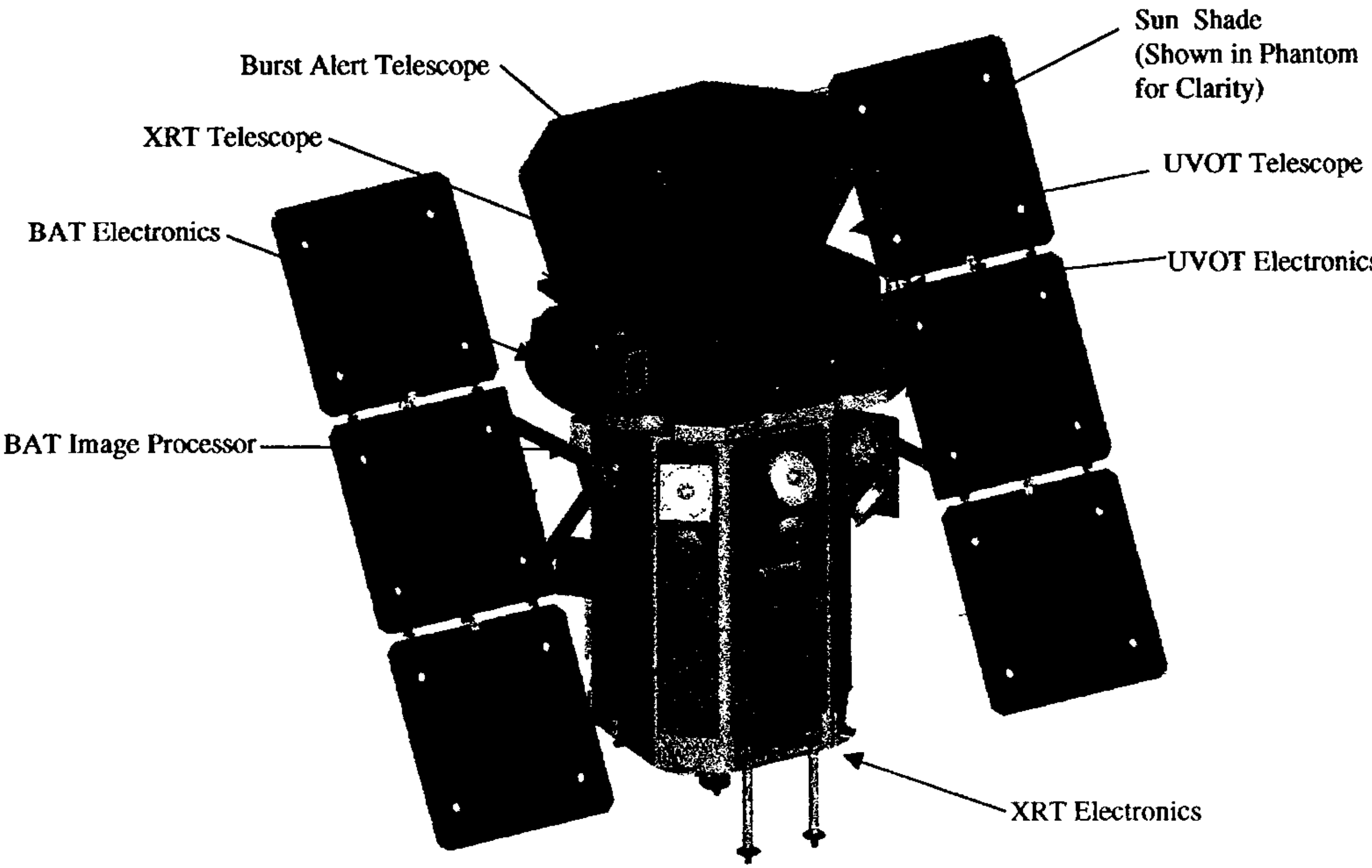
Mission Overview/ Assessment

Tim Gehringer

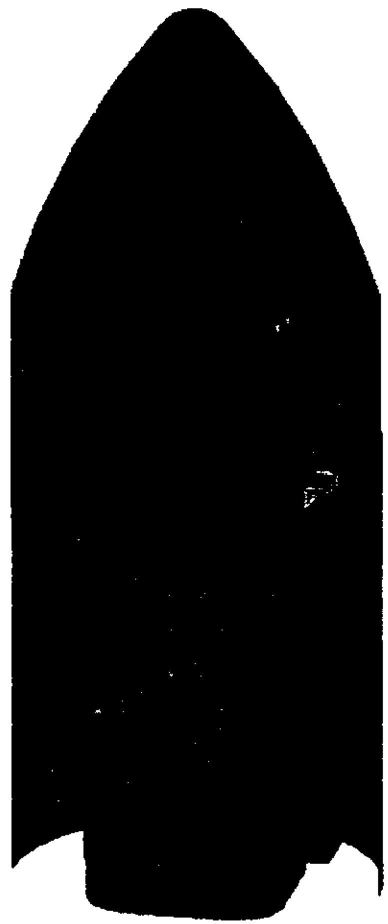
NASA/GSFC

Project Manager

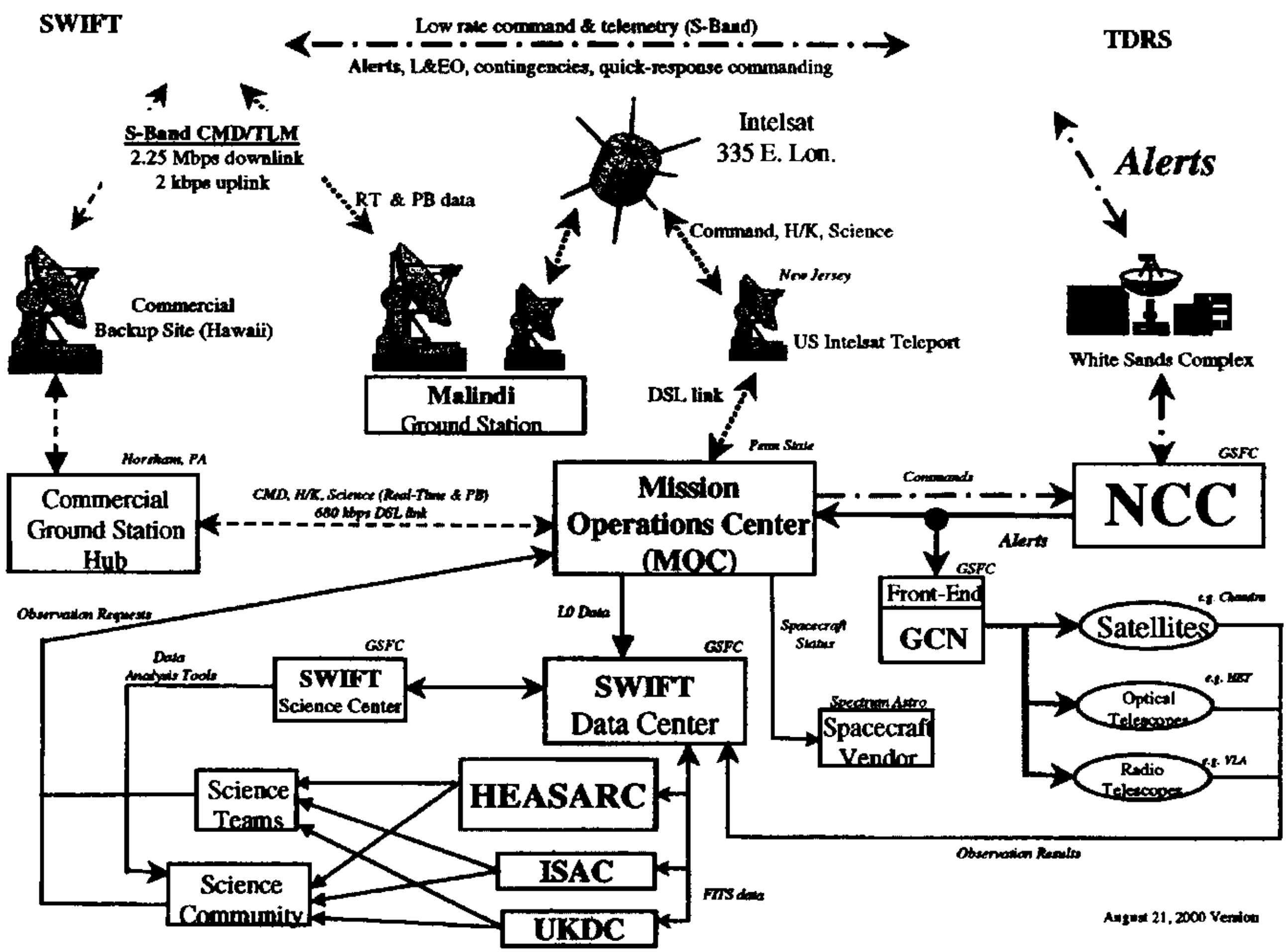
Swift


Burst Alert Telescope
XRT Telescope
BAT Electronics
BAT Image Processor
Sun Shade
(Shown in Phantom
for Clarity)
UVOT Telescope
UVOT Electronics
XRT Electronics

Launch Configuration



Swift Operations



International Agreements

International Agreements Status

- NASA/PPARC-MSSL (UVOT)- Signed
- NASA/PPARC-UL (XRT) - Signed
- NASA/ASI- UB (XRT & Malindi) - In Code I @ HQ
  - Hold up due to Liability Clause issue
  - Starting to cause difficulty negotiating technical interfaces with Malindi.

Risk Management

- Swift has since its inception labored to balance a traditional approach to mission design with the FBC model. For example Swift:
  - Redundant spacecraft bus (except for battery)
  - BAT fully redundant
  - UVOT fully redundant
  - Full GEVS T&E approach with all hardware qualified prior to acceptance at the Observatory level.
- In compliance with NPG 7120.5 the mission has a Risk Management Plan.

Top 5 Risks

- Swift Mission Top 5 risks
  - BAT instrument delivery
  - International collaboration(s)
  - S/C battery SPV not flight proven
  - XRT instrument delivery
  - Contamination Control

Cost Cap

	Phase A	CRR	Variance
Cost Cap			
(Excluding CS Labor & Travel)	$153.9	$164.5	$10.6*
Program APA			
(Available after descopes considered)	-	$2.5	$2.5
Total Cost Cap with APA	$153.9	$167.0	$13.1

Cont. on Dev. CTC w/o APA	$12.8 (13%)	$11.0 (16%)
Cont. on Dev. CTC w/APA	$12.8 (13%)	$13.5 (20%)

*** NIAT $6.8, Contingency $2.6, Launch Vehicle $1.2**

Reserve Chart

WBS	Cost to Complete	Contin. %	Contin. $
Program Management	8,097	20%	1,567
Science (incl. PSU cost)	1,692	5%	85
Systems Engineering	367	10%	37
Spacecraft	20,926	10%	2,093
BAT Instrument/Opt. Bnch.	11,521	30%	3,456
XRT Instrument (PSU)	7,283	30%	2,185
UVOT Instrument (PSU)	2,200	15%	330
Obs. I&T (PSU)	907	10%	91
Mission I&T (w/o SA)	1,698	20%	340
Mission I&T (SA)	4,891	5%	245
Grnd. Data Sys. (inc. PSU)	5,727	10%	573
IV&V	1,400	0%	0
Other: (no conting. applied)			
BAT IP	800	0%	0
SUBALLOT TO MSFC	450	0%	0
E&PO	1,423	0%	0
Cost to Complete	**69,382**		
Total Contingency			**11,000**
Contingency %			**16%**

Descope Plan

- Descope Plan from the Phase A report

Descope Option	Probable Savings	Decision Dates	Impacts of Descope
Reduced Detector Array 50%	$1.2M + Schedule, Mass, Power, Margins	July, 2001	Reduced spares, sensitivity, graceful degradation
Reduce mission life to 1 year	$5.6M	Now thru Phase E	Less science

Additional Descope Options

Descope Option	Probable Savings	Decision Dates	Impacts of Descope
Reduce EPO program from 1.7% to minimum 1% requirement	$1.1M	Anytime	Reduced effectiveness of Swift EPO
Delete fourth solid motor segment	$0.7M	3/01	1. Lower science efficiency 2. Higher radiation background.

Potential savings of $1.8M if all descope options are exercised.

Conclusions

- All of the mission elements of the Swift mission are making excellent progress.
  - All PDR's were successfully completed
- Swift has adequate budget and schedule reserves to complete this mission.
- Mass and Power reserves are adequate
- Swift is ready to proceed into implementation.
  - CDR scheduled June, 2001